NEXUS BETWEEN WATER THEFT AND THE LEVEL OF NON-REVENUE WATER IN NYERI COUNTY

Maina Michael Mwangi.
Masters in Biostatistics, Karatina University, Kenya.

International Academic Journal of Human Resource and Business Administration

(IAJHRBA) | ISSN 2518-2374

Received: 2nd September 2023

Published: 13th November 2023

Full Length Research

Available Online at: https://iajournals.org/articles/iajhrba_v4_i3_453_463.pdf

Citation: Maina, M. M. (2023). Nexus between water theft and the level of non-revenue water in nyeri county. *International Academic Journal of Human Resource and Business Administration, 4*(3), 453-463.

ABSTRACT

Strategies to reduce water losses have been developed and are practiced worldwide. Whilst developed countries have to cope mainly with physical losses, developing countries are also facing the issue of commercial losses including water meters inaccuracies and water thefts. In spite of the establishment of a water loss control unit and various action plans launched by the ministry in-charge of water to reduce NRW, the water losses in Kenya water supply system still remain high. Over the past decades, the water situation for Nyeri County has changed from one of relative abundance to one of relative scarcity. This is because the population growth and rapid urbanization are imposing rapidly growing demands and pressure on the water resources. This is coupled with high levels of NRW due to high leakage and inefficient maintenance of pipe network which has resulted into customer complaints and huge financial losses. The purpose of this research study was to scrutinize the nexus between water theft and the level of non-revenue water in Nyeri County. For the purpose of this study, case study design of research was used. The study was carried out in Nyeri County, Kenya. It focused on the water supply region in the areas of jurisdiction of the five water services providers in the county. The unit of observation was the 270 employees in top, middle and low level management in the companies. From the population of 270, a sample of 30% from within each group in proportions that each group bear to the population as a whole was taken. In this research, semi-structured questionnaires were the instruments used. Data that was collected from the field was coded, and entered into and analyzed using statistics software (SPSS, Version 27.0). This study adopted both descriptive and inferential statistics. The study found out that water theft determines the overall level of non-revenue water in the organization to a moderate extent. The study further established that measures taken by the company to address the problem of NRW caused by water theft are: to fight illegal water connections and there is reliable water supply in all the areas with water distribution network. The study concluded that aspects of water theft such as individual perception, corruption and intermittent water supply are the major contributors of non-revenue water in Nyeri County, Kenya. The study recommended that the companies should come up with measures of curbing water theft which is a great contributor to the increase in non-revenue water. This can be made by routine checks of the company infrastructure to ensure that there are no illegal connections that the company cannot account for.

Key Words: Non-revenue water, Water theft, Maintenance of pipe network, Customer complaints, Water services providers

INTRODUCTION

Water is an indispensable resource crucial for sustaining life, agriculture, industries, and overall economic development (United Nations, 2021). However, the challenges associated with water management are becoming increasingly complex, with one significant issue being the global concern of non-revenue water (NRW). Non-revenue water refers to water that is produced and lost before reaching the end-users, encompassing both physical losses (leakages) and commercial losses (water theft and unauthorized consumption). Across the globe, non-revenue water has emerged as a critical concern for water utilities and policymakers. According to a report by the World Bank, an estimated 32 billion cubic meters of water is lost annually due to non-revenue water, accounting for approximately $14 billion in economic losses (World Bank, 2021). Various studies have highlighted the multifaceted nature of NRW, with factors such as aging infrastructure, inadequate maintenance, and theft contributing significantly.

The issue of water theft, in particular, has gained prominence in recent literature. Countries worldwide, from developed nations to developing economies, are grappling with the challenge of securing their water supply systems against theft (Brouwer & Hofkes, 2021). The motivations for water theft vary, ranging from socio-economic factors to inadequate enforcement of regulations. In Singapore, for instance, the implementation of advanced metering infrastructure and smart technologies has proven effective in reducing NRW (Ng & Leong, 2020). In developed countries like Germany and the United States, emphasis is placed on proactive leak detection technologies and comprehensive water auditing systems. Conversely, in developing nations, challenges often revolve around the lack of resources, outdated infrastructure, and inadequate governance (Liu & Hou, 2021).

African countries face unique challenges in water management, and the issue of non-revenue water is particularly pronounced across the continent. The scarcity of water resources, coupled with rapid urbanization and population growth, places immense pressure on existing water infrastructure. Several African nations grapple with high levels of non-revenue water, often resulting from a combination of factors, including aging infrastructure, insufficient maintenance, and, significantly, water theft. In South Africa, there have been challenges of water scarcity, exacerbated by factors such as climate variability and population growth. Water theft, including illegal connections and tampering with infrastructure, has been a significant contributor to non-revenue water. In response, South Africa has implemented comprehensive water management strategies, including community engagement initiatives, the use of smart technologies, and policy reforms (Gupta & Tyagi, 2022). Nigeria also grapples with complex water management issues. The challenge of non-revenue water is prevalent, with factors such as aging infrastructure, insufficient metering, and water theft contributing to losses. In Nigerian urban areas, unauthorized connections and siphoning of water are common occurrences (Oyedepo, 2020). Efforts are being made to improve infrastructure and implement technological solutions to curb water theft and reduce non-revenue water. In Uganda,

water theft, particularly in informal settlements, is a significant issue. The lack of adequate metering infrastructure and the prevalence of illegal connections contribute to non-revenue water. Uganda has initiated projects to upgrade water infrastructure, improve metering, and raise awareness about responsible water use to address these challenges (Okidi & Okotto, 2021).

Kenya faces a combination of challenges in its water sector. Non-revenue water is a pressing issue, with water theft being a significant contributor. In urban and peri-urban areas, illegal connections, tampering with meters, and unauthorized water abstraction contribute to substantial losses. The Kenyan government has recognized the need for reforms, including the adoption of advanced metering technologies, infrastructure upgrades, and regulatory enhancements, to address non-revenue water. The Water Act of 2016 provides a legal framework for these initiatives (Kenya Water Sector Trust Fund, 2022).

Nyeri County, located in the central region of Kenya, grapples with its own set of challenges concerning water management. Rapid urbanization, population growth, and agricultural demands place immense pressure on the water supply infrastructure. Reports from the Nyeri County Water and Sanitation Company (NYEWASCO) indicate a notable percentage of non-revenue water, raising concerns about the sustainability and efficiency of the water supply system. Water theft has been identified as a significant contributor to the high levels of non-revenue water in Nyeri County. Instances of illegal connections, tampering with meters, and unauthorized water extraction pose a threat to the overall water distribution network. Understanding the local nuances of water theft and its correlation with non-revenue water is imperative for designing targeted interventions that address the specific challenges faced by Nyeri County.

Statement of the Problem

Water scarcity is a pressing concern globally, and Kenya, in particular, acknowledges its water-scarce status in the Vision 2030 initiative, emphasizing the importance of water conservation and prudent use of this limited commodity (WASREB, 2020). However, the effective management of water resources faces significant challenges, with one critical issue being the high level of non-revenue water (NRW). The Auditor General's Report for the fiscal year 2017/18 highlighted that elevated levels of NRW pose a serious threat to the financial sustainability of the water sector, echoing concerns about the broader implications for the nation's water security (OAG, 2018).

The Auditor General's report also emphasized that addressing NRW is imperative for the country's water security goals. With current NRW levels, the water sector would need to increase production significantly to meet the existing demand, presenting a risk to future water access if the underlying issues of NRW are not resolved (OAG, 2018). The report underscores the limited nature of water resources, warning that failure to preserve water adequately could result in a 30% gap between freshwater supply and demand by the year 2030.

Despite efforts by the Kenyan government to reform the water sector through the Water Act of 2016 and the establishment of sector benchmarks by the Water Services Regulatory Board (WASREB), NRW remains a persistent threat to the sustainability of many Water Service Providers (WSPs) in the country (WASREB, 2019). Comparatively, Kenya's NRW stands at 45%, a stark contrast to Japan's 10%, indicating the magnitude of the problem. The Japanese International Cooperation Agency (JICA) estimates that Kenya loses up to 430,000 cubic meters (430 million liters) of water annually due to leaks, burst pipes, theft, or meter inaccuracies, translating to a substantial financial loss of Sh12.2 billion (JICA, 2020).

In the specific context of Nyeri County, the water losses due to NRW, although lower than the national average, are still significant, ranging from 18 to 22 percent (Nyarangi, 2023). Despite being comparatively better than other regions in Kenya, these losses hinder the effective utilization of water resources. Recognizing that fewer losses could contribute to more efficient resource utilization and support measures to protect vital water towers, it is imperative to address the issue of NRW in Nyeri County comprehensively. The stark statistics and the financial implications not only affect the operational capacity of water utilities, as seen in Nyeri County's case through NYEWASCO but also have broader implications for the sustainability of water resources at the national level. Urgent and targeted interventions are required to mitigate NRW and water theft, ensuring the efficient use of water resources, financial sustainability of the water sector, and the realization of Kenya's Vision 2030 water security objectives (County Government of Nyeri, 2022). Related research has been conducted both okay and internationally such as Al-Washali et al (2019) who carried out a study on the influence of the amount of water supplied to a distribution system on the reported level of NRW in The Netherlands. Another study was carried out on Parameter Classification System for NRW Management in Water Distribution Networks in China (Jang, 2018). On the same note, Veriava (2019) did a study on NRW and non-revenue life, a reflection on the making and mitigating of water losses in Johannesburg, South Africa. Further, Gichuki (2023) looked at the nexus between water sector reforms and financial performance: a case of water and sewerage companies in Nyeri County, Kenya. None of the studies however focused on the nexus between water theft and the level of non-revenue water in Nyeri County which is the gap that this study sought to fill.

RESEARCH METHODOLOGY

For the purpose of this research, case study design of research was used. The target population for this study was the five water services providers in Nyeri County. The unit of observation was the 270 employees in top, middle and low level management in the companies. This is because the staff is the ones involved in the daily running of the water supply system and as such they are conversant with the subject matter of the study.

Purposeful sampling was used so as to ensure that key personnel who deal with the issue of NRW are part of the respondents. From the population of 270, a sample of 35% was targeted from within each group in proportions that each group bear to the population as a whole.

In this research, semi-structured questionnaires were the instruments used. Documents such as monthly operations reports and the organization structures from the five water utilities in Nyeri County were reviewed during data analysis. The questionnaires were administered using a drop and pick later method to the sampled respondents.

Data that was collected from the field was filtered, sorted and cleaned in line with research objectives. The data was coded, and entered into and analyzed using statistics software (SPSS, Version 27.0). This study adopted both descriptive and inferential statistics. Descriptive statistics including frequencies, percentages, mean scores, and standard deviation were produced for all the quantitative data. Inferential statistics were done using the linear regression which showed the significance of each independent variable. The results were presented using tables.

RESEARCH FINDINGS AND DISCUSSIONS

The respondents of this study were 94 employees working in registered water utilities in Nyeri County. These were: NYEWASCO (Nyeri Water and Sanitation Company) OMWASCO (Othaya Mukurweini Water and Sanitation), MAWASCO (Mathira Water and Sanitation Company), TEAWASCO (Tetu and Aberdare Water and Sanitation Company) and NARUWASCO (Naro Moru Water and Sanitation Company). Out of 94 sampled respondents, 82 correctly filled and returned their questionnaires. This represents a 91.11% response rate. This conforms to Holtom, Baruch, Aguinis and Ballinger (2022) argument that a response rate of 50% is adequate for analysis and reporting and a response rate of 70% and over is excellent. This clearly shows that the response rate in this study was excellent.

Non-revenue Water Levels

The study sought to establish the rating of the respondents on the level of non-revenue water in their company. The findings are as presented in Table 1.

Table 1: Rating of the respondents on the level of non-revenue water in their company

	Frequency	Percentage
Very high	16	19.5
High	42	51.2
Moderate	22	26.8
Low	2	2.4
Total	**82**	**100.0**

According to the findings, majority of the respondents (51.2%) rated the level of non-revenue water in their company as very high, 26.8% as moderate, 19.5% as very high and 2.4%.

Diagnostic Test Results

The study performed diagnostic tests which included; Normality test, heteroscedasticity test, linearity test, multicollinearity test and autocorrelation test.

Normality Test

The normality of the data was confirmed by using the Shapiro-Wilk one sample test. The results are presented in Table 2.

Table 2: Normality Test

	Shapiro		
Variable	**Statistic**	**Df**	**Sig.**
Water Theft	0.784	207	0.217

As presented in Table 2, the Shapiro statistical values of water theft was 0.784 with a significance value greater than 0.05. Therefore, the study concluded that there was a normal distribution of data. This implied that the data points are relatively evenly spread around the mean, which can be advantageous for statistical analyses. Researchers often assume normal distribution because it simplifies certain statistical procedures and allows for the application of parametric tests. It indicates that the data is likely to be more reliable for making generalizations and drawing inferences about the population from which it was drawn.

Linearity Test

The study performed a linear regression using correlation coefficients. According to Maulud and Abdulazeez (2020), the p-values of independent variables were compared using the following criteria. A positive correlation indicates that there is an undeviating effect when the other variable increases. In this case, the p-value would be < 0.00 and the linearity test would show that independent and dependent variables have a linear relationship. The results are presented in Table 3.

Table 3: Linearity Test

Variable		**Level of non-revenue water**
Water theft	Pearson Correlation	0.771
	Sig. (2-tailed)	0.001

The results indicated in Table 3 show that the Pearson r value of water theft was ($r=0.771$, $p<0.05$). This implies that the relationship between the variables studied was positive and highly correlated. Therefore, it can be concluded that there was a linear relationship between variables.

Multicollinearity Test

The study tested the multicollinearity using the variance inflation factor (VIF) followed by a cross-examination of correlation coefficient among variables. The results are presented in Table 4.

Table 4: Collinearity Test

Variable	Statistic	Df	VIF
Water theft	0.819	207	2.854

The results as presented in Table 4 show that the VIF value of water theft was ($VIF=2.854<10$). Bayman and Dexter (2021) observe that a VIF greater than 10 and above is interpreted to indicate a problem of multicollinearity that can affect the study's finding. Therefore, it can be concluded that the variable studied could suffer from multicollinearity test since it had a VIF value below 10.

Autocorrelation Test

Autocorrelation implies that the error terms of the empirical models are not independent of each other. The Durbin-Watson test was used in this study to test whether the data suffer from autocorrelation problem or they are correlated across time. The results are presented in Table 5.

Table 5: Autocorrelation Test

Variable	Durbin Watson
Water theft	2.009

The results as presented in Table 5 indicate that the Durbin Watson value was 2.009. According to Liebhold and Sharov (2020), Durbin Watson statistics range from 0 to 4 where scores closer to 2, that is between 1.5 and 2.5 indicate independent observations, and values closer to 0 or 4 indicate greater positive or negative autocorrelation respectively. Therefore, using Liebhold and Sharov (2020) recommendations, it was concluded that the residuals of the model are not autocorrelated hence inferential statistics can be conducted on the study data.

Regression Analysis Results

The study conducted a multiple linear regression to examine the relationship between the non-revenue water and the predictor variable. Coefficient of determination explains the extent to which changes in the dependent variable can be explained by the change in the independent variable or the percentage of variation in the dependent variable (non-revenue water) that is explained by the

independent variable (water theft).

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.868	0.754	0.751	0.435

The independent variable that was studied, explain 75.1% of the non-revenue water in Nyeri County, Kenya as represented by the adjusted R^2. This therefore means the water theft contributes to 75.1% of non-revenue water in Nyeri County, Kenya, while other factors not studied in this research contributes 24.9% of non-revenue water in Nyeri County, Kenya. Therefore, further research should be conducted to investigate the other (24.9%) factors influencing non-revenue water in Nyeri County, Kenya.

Table 72: ANOVA results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.385	1	46.385	244.776	4.67E-26
	Residual	15.16	80	0.190		
	Total	**61.545**	**81**			

From the ANOVA statistics in Table 7, the processed data, which are the population parameters, had a significance level of 4.67E-26 which shows that the data is ideal for making a conclusion on the population's parameter. The F calculated at 5% Level of significance was 244.776. Since F calculated is greater than the F critical (value = 3.9604), this shows that the overall model was significant i.e. there is a significant relationship between non-revenue water and water theft.

Table 8: Regression Coefficient

		Unstandardized Coefficients		Standardized Coefficients		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	0.861	0.159		5.415	0.000
	Water theft	0.642	0.233	0.427	2.755	0.007

Dependent variable: Non-revenue water.

The coefficient of regression in Table 8 above was used in coming up with the model below:

$NRW = 0.861 + 0.642X_1$

From the model, taking all factors constant at zero, non-revenue water in Nyeri County was 0.861. The data findings analyzed also shows that a unit increase in water theft will lead to a 0.642 increase in non-revenue water. The variable was significant at 0.007 was less than 0.05 implying that water theft had a statistically significant effect on the level of non-revenue water in Nyeri County.

Conclusions and Recommendations

The study concludes that water theft increases the level of non-revenue water. The study also concludes that aspects of water theft such as individual perception, corruption and intermittent water supply are the major contributors of non-revenue water in Nyeri County, Kenya.

The study therefore recommends that the water companies in Nyeri County should employ competent staff and regularly check their performance to ensure they don't engage in corrupt activities that deny the company's revenue. The study also recommends that the companies should come up with measures of curbing water theft which is a great contributor to the increase in non-revenue water. This can be made by routine checks of the company infrastructure to ensure that there are no illegal connections that the company cannot account for.

REFERENCES

Al-Washali, T., Sharma, S., Al-Nozaily, F., Haidera, M., & Kennedy, M. (2019b). Monitoring nonrevenue water performance in intermittent supply. *Water*, *11*(6), 1–14. https://doi.org/10.3390/w11061220

Bayman, E. O., & Dexter, F. (2021). Multicollinearity in logistic regression models. *Anesthesia & Analgesia*, *133*(2), 362-365.

Brouwer, R., & Hofkes, M. (2021). *Water theft: A global review of case studies*. Water Economics and Policy, 7(3), 2150005. https://doi.org/10.1142/S2382624X21500051

County Government of Nyeri (2022). *In Support of Quality Service Provision in Nyeri's Water Companies*. Retrieved from https://www.nyeri.go.ke/in-support-of-quality-service-provision-in-nyeris-water-companies/

Gichuki, F. G. (2023). Nexus between water sector reforms and financial performance: a case of water and sewerage companies in Nyeri County, Kenya. *International Academic Journal of Innovation, Leadership and Entrepreneurship*, *2*(4), 1-27.

Gupta, S., & Tyagi, V. K. (2022). *Non-revenue water management in South Africa: A case study of integrated approaches*. Sustainable Water Resources Management, 8(1), 5-19. https://doi.org/10.1007/s40899-021-00516-3

Holtom, B., Baruch, Y., Aguinis, H., & A Ballinger, G. (2022). Survey response rates: Trends and a validity assessment framework. *Human relations*, *75*(8), 1560-1584.

Jang, D. (2018). A Parameter Classification System for Nonrevenue Water Management in Water Distribution Networks. *Advances in Civil Engineering*, *2018*, 1–10. https://doi.org/10.1155/2018/3841979

JICA. (2020). *Kenya: Project for Strengthening Capacity in Non-Revenue Water Management*. JICA Project Brief Note. Retrieved from https://us.docs.wps.com/l/sIA_mwI0yvqiRkwY

Kenya Water Sector Trust Fund. (2022). *Nyeri County Water Master Plan*. Retrieved from http://www.kewasnet.co.ke/wp-content/uploads/2022/03/Nyeri-CMP.pdf

Liebhold, A. M., & Sharov, A. A. (2020). Testing for correlation in the presence of spatial autocorrelation in insect count data. In *Population and community ecology for insect management and conservation* (pp. 111-118). CRC Press.

Liu, Y., & Hou, M. (2021). *Water loss management in Germany: A case study of effective policies and practices*. Journal of Water Supply: Research and Technology-AQUA, 70(2), 108-119. https://doi.org/10.2166/aqua.2020.179

Maulud, D., & Abdulazeez, A. M. (2020). A review on linear regression comprehensive in machine learning. *Journal of Applied Science and Technology Trends*, *1*(4), 140-147.

Ng, T. L., & Leong, W. L. (2020). *Smart water metering for non-revenue water reduction: A case study in Singapore*. Journal of Water Process Engineering, 34, 101222. https://doi.org/10.1016/j.jwpe.2020.101222

Nyarangi, E. (2023). *Water PS urges reduction of non-revenue water to meet standards*. Retrieved from https://www.standardmedia.co.ke/health/national/article/2001476875/water-ps-urges-reduction-of-non-revenue-water-to-meet-standards

OAG. (2018). *Report of the Auditor-General on Githunguri Water and Sanitation Company Limited for the Year Ended 30 June 2018*. Kenya National Audit Office, Office of the Auditor General.

Okidi, L. O., & Okotto, L. G. (2021). *Assessing the dynamics of water theft in urban informal settlements in Uganda*. Water Policy, 23(4), 722-739. https://doi.org/10.2166/wp.2021.192

Oyedepo, O. S. (2020). *Water loss management in developing countries: A case study of Nigeria*. Journal of Water, Sanitation and Hygiene for Development, 10(4), 695-703. https://doi.org/10.2166/washdev.2020.021

United Nations. (2021). *World Water Development Report 2021: Valuing Water*. Retrieved from https://www.unwater.org/publications/world-water-development-report-2021

Veriava, A. (2019). Non-revenue water and non-revenue life: A reflection on the making and mitigating of water losses in Johannesburg. *African Studies*, *78*(4), 590–608. https://doi.org/10.1080/00020184.2019.1609760

WASREB. (2019). *Impact Issue No 11/2019 a Performance Report of Kenya's Water Services Sector – 2017/18*. Kenya Vision 2030 & Water Services Regulatory Board.

WASREB. (2020). *Non-Revenue Water Standards* [Water Services Regulatory Board]. https://wasreb.go.ke/nrw-standards/

World Bank. (2021). *Reducing Non-Revenue Water: A Toolkit for Practitioners*. Retrieved from https://openknowledge.worldbank.org/handle/10986/34706